Global Modeling and Assimilation Office

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File Specification for the MERRA Aerosol Reanalysis (MERRAero)

MODIS AOD Assimilation based on a MERRA Replay

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MODIS AOD Assimilation based on a MERRA Replay

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Approved by:

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Steven Pawson Date

Chief, Global Modeling and Assimilation Office
Code 610.1, NASA GSFC

REVISION HISTORY

Version	Revision Date	Extent of Changes
1.0	08/11/2015	Baseline

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1. Introduction

This document describes the gridded output files produced by the Goddard Earth Observing System version 5 (GEOS-5) Goddard Aerosol Assimilation System (GAAS) from July 2002 through December 2014. The MERRA Aerosol Reanalysis (MERRAero) is produced with the hydrostatic version of the GEOS-5 Atmospheric Global Climate Model (AGCM). In addition to standard meteorological parameters (wind, temperature, moisture, surface pressure), this simulation includes 15 aerosol tracers (dust, sea-salt, sulfate, black and organic carbon), ozone (O_3), carbon monoxide (CO) and carbon dioxide (CO_2). This model simulation is driven by prescribed sea-surface temperature and sea-ice, daily volcanic and biomass burning emissions, as well as high-resolution inventories of anthropogenic emission sources. Meteorology is replayed from the MERRA Reanalysis (Rienecker *et al.,* 2008, 2011).

MERRAero includes assimilation of Aerosol Optical Depth (AOD) observations from the Moderate Resolution Imaging Spectroradiometer (MODIS) sensor on both the Terra and Aqua satellites. The AOD assimilation algorithm involves cloud screening and homogenization of the observing system by means of a Neural Net scheme that translates cloud-cleared MODIS reflectances into Aerosol Robotic Network (AERONET) calibrated AOD (referred to here as "MODIS NNR", where NNR refers to a Neural Net-derived retrieval). In this system, reflectances (instead of retrieved AOD) provide the main input, alongside solar and viewing geometry, MODIS cloud cover, climatological surface albedo and model derived surface wind speed. On-line quality control is performed with the adaptive buddy check of Dee et al. (2001), with observation and background errors estimated using the maximum likelihood approach of Dee and da Silva (1999). The AOD analysis in GEOS-5 is performed by means of analysis splitting. First, a 2-D analysis of AOD is performed using error covariances derived from innovation data. The 3-D analysis increments of aerosol mass concentration are then computed using an ensemble formulation for the background error covariance. In MERRAero, as well as in the GEOS-5 near real-time system, this calculation is performed using the Local Displacement Ensemble (LDE) methodology under the assumption that ensemble perturbations represent misplacements of the aerosol plumes. These ensemble perturbations are generated with full model resolution, without the need for multiple model runs. A more detailed description of the GEOS-5 model configuration used for this simulation can be found in Buchard *et al.* (2015).

The simulation is performed at a horizontal resolution of 0.5 degree latitude by 0.625 degree longitude, with 72 vertical layers extending up to 0.01 hPa (~80 km). The majority of the data products are instantaneous with some 2D diagnostic fields being time-averaged. All 3D output is 3-hourly, while 2D output are either hourly or 3-hourly. All 3D output is on the model's native 72-layer hybrid sigma-pressure vertical grid or the vertical dimension is used to represent wavelength. Unlike MERRA, no output is given on constant pressure levels. Section 4 presents additional details on horizontal and vertical grids. Information of the model hybrid sigma-pressure levels can be found in Appendix A.

The GEOS-5 data products are organized into file collections that are described in detail in Appendix B. Additional details about variables listed in this file specification can be found in a separate document, the *GEOS-5 File Specification Variable Definition Glossary.* Information on the scientific quality of this simulation appear in Kishcha *et al.* (2013, 2015), Yi *et al.* (2014), Buchard *et al*. (2015), and Buchard *et al.* (*submitted,* 2016). Documentation about the current

access methods for products described in this document can be found on the GEOS-5 MERRAero portal: https://gmao.gsfc.nasa.gov/reanalysis/merra/MERRAero/.

2. Format and File Organization

GEOS-5 files are generated with the Network Common Data Form (NetCDF-4) library, which uses Hierarchical Data Format Version 5 (HDF-5) as the underlying format. NetCDF-4 is an open-source product of UCAR/Unidata (https://www.unidata.ucar.edu/software/netcdf/) and HDF-5 is developed by the HDF Group (http://www.hdfgroup.org/). One convenient method of reading GEOS-5 files is to use the netCDF library, but the HDF-5 library can also be used directly. These files can be easily read by applications such as IDL, Matlab, GrADS, FERRET, NCL, Panoply as well in Python using the netCDF4, h5py or PyTables packages.

Each GEOS-5 file contains a collection of geophysical quantities that we will refer to as “fields” or “variables” as well as a set of coordinate variables that contain information about the grid coordinates. While the coordinate variables are COARDS and CF-1.0 compliant, the metadata associated with the data variables may not strictly meet all recent CF requirements.

All products are chunked and internally compressed with a GZIP-based method that is transparent to the user. This method slightly degrades the precision of the data, but every effort has been made to ensure that differences between the product and the original, uncompressed data are not scientifically meaningful. Once the precision has been degraded, the files are written using the standard GZIP deflation available in NetCDF-4. When reading these files the NetCDF-4 Library will automatically decompress these files without any specific input from the user.

2.1 Dimensions

GMAO NetCDF-4 files contain dimension variables that can be identified and interpreted by the *units* and *positive* metadata attributes, as defined in the CF metadata conventions. The *units* attribute uses standard UDUNITS terminology to define specific coordinate variables, e.g., latitude, while the *positive* attribute defines whether a vertical coordinate increases or decreases from the surface to the top of the atmosphere. Some 3D products are defined on model layers rather than pressure coordinates and the units attribute is set to layer. **N. B.: For some collections, the level dimension corresponds to wavelength.** This is allowed under the CF conventions to be backward compatible with the older COARDS conventions.

Table 2.1-1. Dimension Variables Contained in GMAO NetCDF-4 Files

Name	**Description**	**Type**	***units* attribute**	***positive* attribute (3D only)**
lon	longitude	double	degrees_east	n/a
lat	latitude	double	degrees_north	n/a
lev (3D only)	layer index or wavelength	double	hPa, layer, m	Down
time	minutes since reference date & time	int	minutes	n/a

2.2 Variables

GMAO NetCDF-4 files are written using the NetCDF classic model. Arrays of scientific data are stored as variables of type **float** that contain various attributes such as *units*, *long_name*, *standard_name*, *_FillValue*, and others. Please note that we do not guarantee that the value in the *standard_name* attribute will conform to the CF metadata conventions. You can quickly list the variables as well as the complete structure of the file by using common utilities such as *ncdump* or *h5dump*. The utilities are distributed with the NetCDF and HDF-5 distributions.

Table 2.2-1 Metadata attributes associated with each variable.

Name	**Type**	**Description**
_FillValue	float	Floating-point value used to identify missing data. Will normally be set to 1e15. Required by CF.
missing_value	float	Same as _FillValue. Included for backward compatibility.
valid_range	float32, array(2)	This attribute defines the valid range of the variable. The first element is the smallest valid value and the second element is the largest valid value. Required by CF, but this attribute is not loaded with useful data.
long_name	String	An ad hoc description of the variable as required by COARDS. It approximates the standard names as defined in an early version of CF conventions. (See References). The *Description* column from the tables of Section 6 is based on this name.
standard_name	String	Same as long_name.
Units	String	The units of the variable. Must be a string that can be recognized by UNIDATA's Udunits package.
scale_factor	float32	If variable is packed as 16-bit integers, this is the scale_factor for expanding to floating-point. Currently we do not plan to pack data, thus value will be 1.0.
add_offset	float32	If variable is packed as 16-bit integers, this is the offset for expanding to floating-point. Currently, we do not plan to pack data, thus value will be 0.0.

2.3 Global Attributes

In addition to scientific variables and dimension scales, global metadata is also stored in GMAO NetCDF-4 files. These metadata attributes are largely defined by the CF/COARDS conventions.

Table 2.3-1 Global metadata attributes associated with each variable.

Name	Type	Description
Conventions	character	Identification of the file convention used, currently “COARDS”
Title	character	Contains information about frequency, dimensionality, resolution and short description of the collection.
History	character	Processing history.
Institution	character	“NASA Global Modeling and Assimilation Office”
Source	character	CVS tag of this release. CVS tags are used internally by the GMAO to designate versions of the system.
References	character	GMAO website address
Comment	character	Identifies this experiment.

3. Instantaneous versus Time-averaged Products

Each file collection listed in Appendix B contains either instantaneous or time-averaged products, but not both. All files contain a single time step with the date and time being part of the filename. Instantaneous collections contain fields written every hour or every 3 hours. Time-averaged collections contain three-hourly means, time-stamped with the central time of the interval. Three-hourly time-averaged files contain averages over time intervals centered and time stamped at 01:30 UTC, 4:30 UTC, 07:30 UTC, and so on. The monthly files contain monthly averages for each hour or 3 hours of the day.

4. Grid Structure

4.1 Horizontal Structure

The version of the GEOS-5 used for this simulation utilizes a cubed-sphere horizontal grid (*e.g.*, Putman and Lin 2007). However, all datasets provided here are given on a logically rectangular longitude-latitude grid. Files are produced on a *full resolution* $0.5^o \times 0.625^o$ latitude by longitude grid. The horizontal native grid origin, associated with variables indexed (i=1, j=1) represents a grid point located at (180°W, 90°S). Latitude and longitude of grid points as a function of their indices (i, j) can be determined by:

$$\lambda_i = -180 + (i-1)\Delta\lambda, \quad i = 1, ..., I$$
$$\varphi_j = -90 + (j-1)\Delta\varphi, \quad j = 1, ..., J$$

Mesh sizes (Δφ, Δλ) and total number of grid points (I, J) are given in the table below.

Resolution	I	Δλ	J	Δφ
Full	361	0.5^o	576	0.625^o

4.2 Vertical Structure

Gridded products use three different vertical configurations: horizontal-only (can be vertical averages, single level, or surface values), wavelength, and model-level. Assuming Fortran indexing, horizontal-only data for a given variable appear as 3-dimensional fields (x, y, time), while model-level data appear as 4-dimensional fields (x, y, z, time). When the vertical dimension represents wavelength, the variable appears as a 3-dimensional field (x, y, wavelength). In all cases the time dimension spans multiple files, as each file (granule) contains only one time. The model layers used for GEOS-5 products are on a hybrid sigma-pressure coordinate system: terrain following sigma for most of the troposphere, and constant pressure coordinates for the upper levels. Model-level data is output on the **72** layers shown in the table of Appendix A. The pressure at the model top is a fixed constant, $\mathbf{p_{top}=0.01\ hPa}$. Pressures at model edges should be computed by summing the pressure thickness (variable name *DELP)* starting from $\mathbf{p_{top}}$. (Integrating from the surface will lead to negative pressure at the top due to round-off errors.) Even though the model-level fields are on a hybrid sigma-pressure coordinate and their vertical location could be obtained from coefficients (a_k, b_k) typical of hybrid coordinates, this may change in future GMAO systems. We thus recommend that users rely on the reported 3D pressure distribution, and not use ones computed from the (a_k, b_k) coefficients.

Note that the indexing for the GEOS-5 vertical coordinate system is from top to bottom, i.e., layer 1 is the top layer of the atmosphere, while layer **72** is adjacent to the Earth's surface. Unlike other GEOS-5 data products, the MERRAero pressure level files are written top-down as well.

5. File Naming Conventions

Each GEOS-5 product file will have a complete file name identified in the metadata attribute *comment*.

5.1 File Names

The standard generic complete name for the GEOS-5 data products will appear as follows:

dR_MERRA-AA-r2.collection.timestamp.nc4

A brief description of each file name nodes follow:

dR_MERRA-AA-r2: The **dR_MERRA-AA-r2** indicates the experiment name where the "d" token indicates the resolution of the cubed-sphere grid..

collection: The operational GEOS-5 data are organized into file *collections* that contain fields with common characteristics. These collections are used to make the data more accessible for specific purposes. Collection names are of the form

freq_dims_group_HV

where the four attributes (*freq, dims, group, HV*) are:

***freq**:* time-independent (**const**), instantaneous (**inst*F*hr),** time-average (**tavg*F*hr**), diurnally time-averaged (**tdav*F*hr**) where *F* indicates the frequency or averaging interval and can be any of the following:
3hr = every 3 hours
1hr = hourly
The **tdav**F files typically contain monthly diurnal files, meaning, monthly means for each hour of the day: 0 UTC, 1 UTC, …, 23UTC.

dims: **2D** for collections with only 2-dimensional fields or **3D** for collections with a mix of 2- and 3-dimensional fields.

group: A short mnemonic for the type of fields in the collection, or the variable name for single-variable collections.

***HV*:** Horizontal and Vertical grid.

H can be:
N: Nominal (full) horizontal resolution of lat/lon grid.
C: Nominal (full) horizontal resolution of lat/lon grid.
V can be:
x: horizontal-only data (surface, single level, etc.); *dims* must be **2D**
v: model layer centers (see Appendix A); *dims* must be **3D**

e: model layer edges (see Appendix A); *dims* must be **3D**

timestamp: This node defines the date and time associated with the data in the file. It has the form *yyyymmdd_hhmmz*

yyyy – year string (e.g. , "2002")
mm – month string (e.g.., "09" for September)
dd – day of the month string
hh – hour (UTC)
mm – minute

nc4: All files are in NetCDF-4 format, thus the suffix ".nc4".

5.2 Examples

File: dR_MERRA-AA-r2.inst3hr_3d_aer_Nv.20050701_1330z.nc4

This file has the following attributes:

- **dR_MERRA-AA-r2**: MERRAero Run, having dimensions 576 × 361 longitude by latitude.
- **inst1hr**: Instantaneous, every 3 hours
- **3d**: 3-dimensional
- **Nv**: full horizontal resolution, hybrid sigma-pressure vertical coordinates
- **20050701_1330z**: the collection is valid 13:30 UTC on July 1st, 2005

File: dR_MERRA-AA-r2.tavg3hr_2d_aer_Nx.20050805_1130z.nc4

This file has the following attributes:

- **dR_MERRA-AA-r2**: MERRAero Run, having dimensions 576 × 361 longitude by latitude.
- **tavg3hr**: Time averaged, 3-hourly
- **2d**: 2-dimensional
- **aer**: This collection has multiple variables with aerosol/carbon diagnostics.
- **Nx**: single-level variables
- **20050805_1130z**: the collection is valid 11:30 UTC on August 5th, 2005

6. Metadata

The following CF-1.0 metadata are included in the files:

- Space-time grid information (dimension variables)
- Variable names and descriptions
- Variable units
- "Missing" value for each variable

Grid information and units comply with the CF-1.0 conventions. Most variables, but not all, will conform to CF conventions for identification by having a valid "standard_name" attribute defined.

References

Buchard, V., A. M. da Silva, P. R. Colarco, A. Darmenov, C. A. Randles, R. Govindaraju, O. Torres, J. Campbell, and R. Spurr (2015a), Using the OMI Aerosol Index and Absorption Aerosol Optical Depth to evaluate the NASA MERRA Aerosol Reanalysis, *Atmos. Chem. Phys*. 15(10):5743–5760, 2015. doi: 10.5194/acp-15-5743-2015.

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Yi, Bingqi, P. Yang, A. Dessler and A.M. da Silva, (2014), Response of aerosol direct radiative effect to the East Asian summer monsoon. *IEE Geosci. Remote Sensing,* 12, 597-600.

Web Resources

GMAO web site: http://gmao.gsfc.nasa.gov/
NetCDF information: http://www.unidata.ucar.edu/software/netcdf/
CF Standard Description: http://cf-pcmdi.llnl.gov/
The HDF Group: http://www.hdfgroup.org /

Acronyms

AERONET	Aerosol Robotic Network
AOT/AOD	Aerosol Optical Thickness/Aerosol Optical Depth
CF	Climate and Forecast metadata convention
CO	Carbon monoxide
CO2	Carbon dioxide
COARDS	Cooperative Ocean/Atmosphere Research Data Service metadata convention
DMS	di-methyl sulfide
GMAO	Global Modeling and Assimilation Office
HDF	Hierarchical Data Format
MODIS	Moderate Resolution Imaging Spectroradiometer
MSA	methane sulphonic acid
NetCDF	Network Common Data Form
SO2	Sulfur dioxide
SO4	Sulfate
TOA	Top Of the Atmosphere
TOMS	Total Ozone Mapping Spectrometer
UTC	Universal Time, Coordinated

Appendix A: Vertical Structure

Hybrid Sigma-Pressure Levels

Products on the native vertical grid will be output on the following levels. Pressures are nominal for a 1000 hPa surface pressure and refer to the top edge of the layer. Note that the bottom layer has a nominal thickness of 15 hPa.

Lev	***P(hPa)***	***Lev***	***P(hPa)***	***Lev***	***P(hPa)***	***Lev***	***P(hPa)***	***Lev***	***P(hPa)***	***Lev***	***P(hPa)***
1	0.0100	13	0.6168	25	9.2929	37	78.5123	49	450.000	61	820.000
2	0.0200	14	0.7951	26	11.2769	38	92.3657	50	487.500	62	835.000
3	0.0327	15	1.0194	27	13.6434	39	108.663	51	525.000	63	850.000
4	0.0476	16	1.3005	28	16.4571	40	127.837	52	562.500	64	865.000
5	0.0660	17	1.6508	29	19.7916	41	150.393	53	600.000	65	880.000
6	0.0893	18	2.0850	30	23.7304	42	176.930	54	637.500	66	895.000
7	0.1197	19	2.6202	31	28.3678	43	208.152	55	675.000	67	910.000
8	0.1595	20	3.2764	32	33.8100	44	244.875	56	700.000	68	925.000
9	0.2113	21	4.0766	33	40.1754	45	288.083	57	725.000	69	940.000
10	0.2785	22	5.0468	34	47.6439	46	337.500	58	750.000	70	955.000
11	0.3650	23	6.2168	35	56.3879	47	375.000	59	775.000	71	970.000
12	0.4758	24	7.6198	36	66.6034	48	412.500	60	800.000	72	985.000

Appendix B. List of File Collections

B.1 Instantaneous Collections

inst1hr_2d_hwl_Nx: Selected Aerosol Diagnostics

Frequency: *1-hourly from 23:00 UTC (instantaneous)*
Spatial Grid: *2D, single-level, full horizontal resolution*
Dimensions: *longitude=576, latitude=361, time=1*
Granule Size: *~7 MB*

	Dim	*Description*	*Units*
BCEXTTAU	tyx	Black Carbon Extinction AOT [550 nm]	1
BCSMASS	tyx	Black Carbon Surface Mass Concentration	kg m^{-3}
CO2CL	tyx	CO2 Column Load Bin 001	kg m^{-2}
COCL	tyx	CO Column Burden	kg m^{-2}
DUEXTTAU	tyx	Dust Extinction AOT [550 nm]	1
DUSMASS	tyx	Dust Surface Mass Concentration	kg m^{-3}
DUSMASS25	tyx	Dust Surface Mass Concentration - PM 2.5	kg m^{-3}
OCEXTTAU	tyx	Organic Carbon Extinction AOT [550 nm]	1
OCSMASS	tyx	Organic Carbon Surface Mass Concentration (Particulate Matter)	kg m^{-3}
PCU	tyx	convective rainfall	kg m^{-2} s^{-1}
PLS	tyx	large scale rainfall	kg m^{-2} s^{-1}
SLP	tyx	sea level pressure	Pa
SO2SMASS	tyx	SO2 Surface Mass Concentration	kg m^{-3}
SO4SMASS	tyx	SO4 Surface Mass Concentration	kg m^{-3}
SSEXTTAU	tyx	Sea Salt Extinction AOT [550 nm]	1
SSSMASS	tyx	Sea Salt Surface Mass Concentration	kg m^{-3}
SSSMASS25	tyx	Sea Salt Surface Mass Concentration - PM 2.5	kg m^{-3}
SUEXTTAU	tyx	SO4 Extinction AOT [550 nm]	1
TOTANGSTR	tyx	Total Aerosol Angstrom parameter [470-870 nm]	1
TOTEXTTAU	tyx	Total Aerosol Extinction AOT [550 nm]	1
TOTSCATAU	tyx	Total Aerosol Scattering AOT [550 nm]	1

inst3hr_2d_aaod_Nc: Speciated Aerosol Absorption Optical Depth

Frequency: *3-hourly from 21:00 UTC (instantaneous)*
Spatial Grid: *2D, multiple-channels, full horizontal resolution*
Dimensions: *longitude=576, latitude=361, level=12, time=1*
Levels: 12 wavelengths (340, 380, 440, 470, 500, 550, 670, 865, 1024, 1064, 2130 µm)
Granule Size: *~51 MB*

Name	*Dim*	*Description*	*Units*
BCphilic	tzyx	Hydrophilic Black Carbon AAOD	1
BCphobic	tzyx	Hydrophobic Black Carbon AAOD	1
OCphilic	tzyx	Hydrophilic Organic Carbon (Particulate Matter) AAOD	1
OCphobic	tzyx	Hydrophobic Organic Carbon (Particulate Matter) AAOD	1
SO4	tzyx	Sulfate aerosol AAOD	1
delp	tzyx	Pressure Thickness	Pa
du001	tzyx	Dust (bin 001) AAOD	1
du002	tzyx	Dust (bin 002) AAOD	1
du003	tzyx	Dust (bin 003) AAOD	1
du004	tzyx	Dust (bin 004) AAOD	1
du005	tzyx	Dust (bin 005) AAOD	1
rh	tzyx	Relative Humidity (range 0-1)	percent
ss001	tzyx	Sea Salt (bin 001) AAOD	1
ss002	tzyx	Sea Salt (bin 002) AAOD	1
ss003	tzyx	Sea Salt (bin 003) AAOD	1
ss004	tzyx	Sea Salt (bin 004) AAOD	1
ss005	tzyx	Sea Salt (bin 005) AAOD	1

inst3hr_2d_avk_Nx: AOD Pseudo Analysis Averaging Kernel

Frequency: *3-hourly from 21:00 UTC (instantaneous)*
Spatial Grid: *2D, single-level, full horizontal resolution*
Dimensions: *longitude=576, latitude=361, level=1, time=1*
Granule Size: *~0 MB*

Name	*Dim*	*Description*	*Units*
AOD	tzyx	Total Aerosol Optical Depth	1
delp	tzyx	Pressure Thickness	hPa
rh	tzyx	Relative Humidity	percent

inst3hr_2d_gas_Nx: Aerosol Optical Depth Analysis and Increments

Frequency: *3-hourly from 21:00 UTC (instantaneous)*
Spatial Grid: *2D, single-level, full horizontal resolution*
Dimensions: *longitude=576, latitude=361, time=1*
Granule Size: *~1 MB*

Name	*Dim*	*Description*	*Units*
AODANA	tyx	Aerosol Optical Depth Analysis	1
AODINC	tyx	Aerosol Optical Depth Analysis Increment	1

inst3hr_2d_rad_Nx: Radiation Diagnostics

Frequency: *3-hourly from 21:00 UTC (instantaneous)*
Spatial Grid: *2D, single-level, full horizontal resolution*
Dimensions: *longitude=576, latitude=361, time=1*
Granule Size: *~7 MB*

Name	*Dim*	*Description*	*Units*
cosz	tyx	cosine of the solar zenith angle	1
lw_sfc	tyx	surface net downward longwave flux	W m^{-2}
lw_sfc_clr	tyx	surface net downward longwave flux assuming clear sky	W m^{-2}
lw_sfc_clr_na	tyx	surface net downward longwave flux assuming clear sky and no aerosol	W m^{-2}
lwdn_sfc	tyx	surface absorbed longwave radiation	W m^{-2}

lwdn_sfc_clr	tyx	surface absorbed longwave radiation assuming clear sky	W m^{-2}
lwdn_sfc_clr_na	tyx	surface absorbed longwave radiation assuming clear sky and no aerosol	W m^{-2}
lwup_sfc	tyx	longwave flux emitted from surface	W m^{-2}
netrad_sfc	tyx	net downwelling radiation at surface	W m^{-2}
olr	tyx	upwelling longwave flux at toa	W m^{-2}
olr_clr	tyx	upwelling longwave flux at toa assuming clear sky	W m^{-2}
olr_clr_na	tyx	upwelling longwave flux at toa assuming clear sky and no aerosol	W m^{-2}
sw_sfc	tyx	surface net downward shortwave flux	W m^{-2}
sw_sfc_clr	tyx	surface net downward shortwave flux assuming clear sky	W m^{-2}
sw_sfc_clr_na	tyx	surface net downward shortwave flux assuming clear sky and no aerosol	W m^{-2}
sw_sfc_na	tyx	surface net downward shortwave flux assuming no aerosol	W m^{-2}
sw_toa	tyx	toa net downward shortwave flux	W m^{-2}
sw_toa_clr	tyx	toa net downward shortwave flux assuming clear sky	W m^{-2}
sw_toa_clr_na	tyx	toa net downward shortwave flux assuming clear sky and no aerosol	W m^{-2}
sw_toa_na	tyx	toa net downward shortwave flux assuming no aerosol	W m^{-2}
swdn_sfc	tyx	surface incoming shortwave flux	W m^{-2}
swdn_sfc_clr	tyx	surface incoming shortwave flux assuming clear sky	W m^{-2}
swdn_sfc_clr_na	tyx	surface incoming shortwave flux assuming clear clean sky	W m^{-2}
swdn_sfc_na	tyx	surface incoming shortwave flux assuming clean sky	W m^{-2}
swdn_toa	tyx	toa incoming shortwave flux	W m^{-2}
swup_sfc	tyx	surface outgoing shortwave flux	W m^{-2}
swup_sfc_clr	tyx	surface outgoing shortwave flux assuming clear sky	W m^{-2}
swup_sfc_clr_na	tyx	surface outgoing shortwave flux assuming clear clean sky	W m^{-2}
swup_sfc_na	tyx	surface outgoing shortwave flux assuming clean sky	W m^{-2}
swup_toa	tyx	toa outgoing shortwave flux	W m^{-2}
swup_toa_clr	tyx	toa outgoing shortwave flux assuming clear sky	W m^{-2}
swup_toa_clr_na	tyx	toa outgoing shortwave flux no aerosol clear sky	W m^{-2}
swup_toa_na	tyx	toa outgoing shortwave flux no aerosol	W m^{-2}

inst3hr_2d_taod_Nc: Speciated Aerosol Total Optical Depth

Frequency: *3-hourly from 21:00 UTC (instantaneous)*
Spatial Grid: *2D, multiple-channels, full horizontal resolution*
Dimensions: *longitude=576, latitude=361, level=12, time=1*
Levels: 12 wavelengths (340, 380, 440, 470, 500, 550, 670, 865, 1024, 1064, 2130 μm)
Granule Size: *~67 MB*

Name	*Dim*	*Description*	*Units*
BCphilic	tzyx	Hydrophilic Black Carbon AOD	1
BCphobic	tzyx	Hydrophobic Black Carbon AOD	1
OCphilic	tzyx	Hydrophilic Organic Carbon (Particulate Matter)	1
OCphobic	tzyx	Hydrophobic Organic Carbon (Particulate Matter)	1
SO4	tzyx	Sulphate aerosol AOD	1
delp	tzyx	Pressure Thickness	Pa
du001	tzyx	Dust (bin 001) AOD	1
du002	tzyx	Dust (bin 002) AOD	1
du003	tzyx	Dust (bin 003) AOD	1
du004	tzyx	Dust (bin 004) AOD	1
du005	tzyx	Dust (bin 005) AOD	1
rh	tzyx	Relative Humidity	percent
ss001	tzyx	Sea Salt (bin 001) AOD	1
ss002	tzyx	Sea Salt (bin 002) AOD	1
ss003	tzyx	Sea Salt (bin 003) AOD	1
ss004	tzyx	Sea Salt (bin 004) AOD	1
ss005	tzyx	Sea Salt (bin 005) AOD	1

inst3hr_2d_xaod_Nc: Non-Speciated Aerosol Absorption and Total Optical Depth

Frequency: *3-hourly from 21:00 UTC (instantaneous)*
Spatial Grid: *2D, multiple-channels, full horizontal resolution*
Dimensions: *longitude=576, latitude=361, level=12, time=1*
Levels: 12 wavelengths (340, 380, 440, 470, 500, 550, 670, 865, 1024, 1064, 2130 μm)
Granule Size: *~9 MB*

Name	*Dim*	*Description*	*Units*
aaod	tzyx	Total Absorption Aerosol Optical Depth	1
taod	tzyx	Total Aerosol Optical Depth	1

inst3hr_3d_aer_Nv: Speciated Aerosol Mixing Ratio

Frequency: *3-hourly from 21:00 UTC (instantaneous)*
Spatial Grid: *3D, model-level, full horizontal resolution*
Dimensions: *longitude=576, latitude=361, level=72, time=1*
Granule Size: *~414 MB*

Name	*Dim*	*Description*	*Units*
AIRDENS	tzyx	air density	kg m^{-3}
BCphilic	tzyx	Hydrophilic Black Carbon	kg kg^{-1}
BCphobic	tzyx	Hydrophobic Black Carbon	kg kg^{-1}
DMS	tzyx	Dimethylsulphide	kg kg^{-1}
LWI	tyx	land(1) water(0) ice(2) flag	1
MSA	tzyx	Methanesulphonic acid	kg kg^{-1}
OCphilic	tzyx	Hydrophilic Organic Carbon (Particulate Matter)	kg kg^{-1}
OCphobic	tzyx	Hydrophobic Organic Carbon (Particulate Matter)	kg kg^{-1}
RH	tzyx	relative humidity after moist	1
SO2	tzyx	Sulphur dioxide	kg kg^{-1}
SO4	tzyx	Sulphate aerosol	kg kg^{-1}
delp	tzyx	pressure thickness	Pa
du001	tzyx	Dust Mixing Ratio (bin 001)	kg kg^{-1}
du002	tzyx	Dust Mixing Ratio (bin 002)	kg kg^{-1}
du003	tzyx	Dust Mixing Ratio (bin 003)	kg kg^{-1}
du004	tzyx	Dust Mixing Ratio (bin 004)	kg kg^{-1}

du005	tzyx	Dust Mixing Ratio (bin 005)	kg kg^{-1}
ps	tyx	surface pressure	Pa
ss001	tzyx	Sea Salt Mixing Ratio (bin 001)	kg kg^{-1}
ss002	tzyx	Sea Salt Mixing Ratio (bin 002)	kg kg^{-1}
ss003	tzyx	Sea Salt Mixing Ratio (bin 003)	kg kg^{-1}
ss004	tzyx	Sea Salt Mixing Ratio (bin 004)	kg kg^{-1}
ss005	tzyx	Sea Salt Mixing Ratio (bin 005)	kg kg^{-1}

inst3hr_3d_aop1064nm_Nv: Aerosol Optical Properties at 1064 nm

Frequency: *3-hourly from 21:00 UTC (instantaneous)*
Spatial Grid: *3D, model-level, full horizontal resolution*
Dimensions: *longitude=576, latitude=361, level=72, time=1*
Granule Size: *~170 MB*

Name	*Dim*	*Description*	*Units*
aback_sfc	tzyx	Aerosol Attenuated Backscatter from Surface [1064 nm]	km^{-1}sr^{-1}
aback_toa	tzyx	Aerosol Attenuated Backscatter from Space [1064 nm]	km^{-1}sr^{-1}
backscat	tzyx	Aerosol Backscatter [1064 nm]	km^{-1}sr^{-1}
delp	tzyx	Pressure Thickness	Pa
ext2back	tzyx	Aerosol Extinction to Backscatter Ratio [1064 nm]	sr^{-1}
extinction	tzyx	Aerosol Extinction [1064 nm]	km^{-1}
rh	tzyx	Relative Humidity	percent
ssa	tzyx	Aerosol Single Scatter Albedo [1064 nm]	none
tau	tzyx	Aerosol Layer Optical Thickness [1064 nm]	none

inst3hr_3d_aop355nm_Nv: Aerosol Optical Properties at 355 nm

Frequency: *3-hourly from 21:00 UTC (instantaneous)*
Spatial Grid: *3D, model-level, full horizontal resolution*
Dimensions: *longitude=576, latitude=361, level=72, time=1*
Granule Size: *~168 MB*

Name	*Dim*	*Description*	*Units*
aback_sfc	tzyx	Aerosol Attenuated Backscatter from Surface [355 nm]	$km^{-1}sr^{-1}$
aback_toa	tzyx	Aerosol Attenuated Backscatter from Space [355 nm]	$km^{-1}sr^{-1}$
backscat	tzyx	Aerosol Backscatter [355 nm]	$km^{-1}sr^{-1}$
delp	tzyx	Pressure Thickness	Pa
ext2back	tzyx	Aerosol Extinction to Backscatter Ratio [355 nm]	sr^{-1}
extinction	tzyx	Aerosol Extinction [355 nm]	km^{-1}
rh	tzyx	Relative Humidity	percent
ssa	tzyx	Aerosol Single Scatter Albedo [355 nm]	none
tau	tzyx	Aerosol Layer Optical Thickness [355 nm]	none

inst3hr_3d_aop532nm_Nv: Aerosol Optical Properties at 532 nm

Frequency: *3-hourly from 21:00 UTC (instantaneous)*
Spatial Grid: *3D, model-level, full horizontal resolution*
Dimensions: *longitude=576, latitude=361, level=72, time=1*
Granule Size: *~169 MB*

Name	*Dim*	*Description*	*Units*
aback_sfc	tzyx	Aerosol Attenuated Backscatter from Surface [532 nm]	$km^{-1}sr^{-1}$
aback_toa	tzyx	Aerosol Attenuated Backscatter from Space [532 nm]	$km^{-1}sr^{-1}$
backscat	tzyx	Aerosol Backscatter [532 nm]	$km^{-1}sr^{-1}$
delp	tzyx	Pressure Thickness	Pa
ext2back	tzyx	Aerosol Extinction to Backscatter Ratio [532 nm]	sr^{-1}
extinction	tzyx	Aerosol Extinction [532 nm]	km^{-1}
rh	tzyx	Relative Humidity	percent
ssa	tzyx	Aerosol Single Scatter Albedo [532 nm]	none
tau	tzyx	Aerosol Layer Optical Thickness [532 nm]	none

inst3hr_3d_asm_Nv: Meteorological Fields

Frequency: *3-hourly from 21:00 UTC (instantaneous)*
Spatial Grid: *3D, model-level, full horizontal resolution*
Dimensions: *longitude=576, latitude=361, level=72, time=1*
Granule Size: *~177 MB*

Name	*Dim*	*Description*	*Units*
CLOUD	tzyx	cloud area fraction	1
H	tzyx	mid layer heights	m
OMEGA	tzyx	vertical pressure velocity	Pa s^{-1}
PHIS	tyx	surface geopotential height	m^{+2} s^{-2}
PS	tyx	surface pressure	Pa
QI	tzyx	mass fraction of cloud ice water	kg kg^{-1}
QL	tzyx	mass fraction of cloud liquid water	kg kg^{-1}
QV	tzyx	specific humidity	kg kg^{-1}
SLP	tyx	sea level pressure	Pa
T	tzyx	air temperature	K
TAUCLI	tzyx	optical thickness for ice clouds	1
TAUCLW	tzyx	optical thickness for liquid clouds	1
U	tzyx	eastward wind	m s^{-1}
V	tzyx	northward wind	m s^{-1}

inst3hr_3d_gas_Nv: Aerosol Analysis Increments

Frequency: *3-hourly from 21:00 UTC (instantaneous)*
Spatial Grid: *3D, model-level, full horizontal resolution*
Dimensions: *longitude=576, latitude=361, level=72, time=1*
Granule Size: *~52 MB*

Name	*Dim*	*Description*	*Units*
AIRDENS	tzyx	air density	kg m^{-3}
BCINC	tzyx	Black Carbon Mixing Ratio Analysis Increments	kg kg^{-1}
DUINC	tzyx	Dust Mixing Ratio Analysis Increments	kg kg^{-1}
OCINC	tzyx	Organic Carbon Mixing Ratio Analysis Increments	kg kg^{-1}
SSINC	tzyx	Sea-salt Mixing Ratio Analysis Increments	kg kg^{-1}
SUINC	tzyx	Sulfate Mixing Ratio Analysis Increments	kg kg^{-1}
delp	tzyx	pressure thickness	Pa

B.2 Time-averaged Collections

tavg3hr_2d_aer_Nx: Aerosol Diagnostics

Frequency: *3-hourly from 22:30 UTC (time-averaged)*
Spatial Grid: *2D, single-leve, full horizontal resolution*
Dimensions: *longitude=576, latitude=361, time=1*
Granule Size: *~48 MB*

Name	*Dim*	*Description*	*Units*
BCANGSTR	tyx	Black Carbon Angstrom parameter [470-870 nm]	1
BCCMASS	tyx	Black Carbon Column Mass Density	kg m^{-2}
BCDP001	tyx	Black Carbon Dry Deposition Bin 001	kg m^{-2} s^{-1}
BCDP002	tyx	Black Carbon Dry Deposition Bin 002	kg m^{-2} s^{-1}
BCEM001	tyx	Black Carbon Emission Bin 001	kg m^{-2} s^{-1}
BCEM002	tyx	Black Carbon Emission Bin 002	kg m^{-2} s^{-1}
BCEMAN	tyx	Black Carbon Anthropogenic Emissions	kg m^{-2} s^{-1}
BCEMBB	tyx	Black Carbon Biomass Burning Emissions	kg m^{-2} s^{-1}
BCEMBF	tyx	Black Carbon Biofuel Emissions	kg m^{-2} s^{-1}
BCEXTTAU	tyx	Black Carbon Extinction AOT [550 nm]	1
BCFLUXU	tyx	Black Carbon column u-wind mass flux	kg m^{-1} s^{-1}
BCFLUXV	tyx	Black Carbon column v-wind mass flux	kg m^{-1} s^{-1}
BCHYPHIL	tyx	Black Carbon Hydrophobic to Hydrophilic	kg m^{-2} s^{-1}
BCSCATAU	tyx	Black Carbon Scattering AOT [550 nm]	1
BCSMASS	tyx	Black Carbon Surface Mass Concentration	kg m^{-3}
BCSV001	tyx	Black Carbon Convective Scavenging Bin 001	kg m^{-2} s^{-1}
BCSV002	tyx	Black Carbon Convective Scavenging Bin 002	kg m^{-2} s^{-1}
BCWT001	tyx	Black Carbon Wet Deposition Bin 001	kg m^{-2} s^{-1}
BCWT002	tyx	Black Carbon Wet Deposition Bin 002	kg m^{-2} s^{-1}
DMSCMASS	tyx	DMS Column Mass Density	kg m^{-2}
DMSSMASS	tyx	DMS Surface Mass Concentration	kg m^{-3}
DUAERIDX	tyx	Dust TOMS UV Aerosol Index	1
DUANGSTR	tyx	Dust Angstrom parameter [470-870 nm]	1
DUCMASS	tyx	Dust Column Mass Density	kg m^{-2}
DUCMASS25	tyx	Dust Column Mass Density - PM 2.5	kg m^{-2}
DUDP001	tyx	Dust Dry Deposition Bin 001	kg m^{-2} s^{-1}

DUDP002	tyx	Dust Dry Deposition Bin 002	kg m^{-2} s^{-1}
DUDP003	tyx	Dust Dry Deposition Bin 003	kg m^{-2} s^{-1}
DUDP004	tyx	Dust Dry Deposition Bin 004	kg m^{-2} s^{-1}
DUDP005	tyx	Dust Dry Deposition Bin 005	kg m^{-2} s^{-1}
DUEM001	tyx	Dust Emission Bin 001	kg m^{-2} s^{-1}
DUEM002	tyx	Dust Emission Bin 002	kg m^{-2} s^{-1}
DUEM003	tyx	Dust Emission Bin 003	kg m^{-2} s^{-1}
DUEM004	tyx	Dust Emission Bin 004	kg m^{-2} s^{-1}
DUEM005	tyx	Dust Emission Bin 005	kg m^{-2} s^{-1}
DUEXTT25	tyx	Dust Extinction AOT [550 nm] - PM 2.5	1
DUEXTTAU	tyx	Dust Extinction AOT [550 nm]	1
DUEXTTFM	tyx	Dust Extinction AOT [550 nm] - PM 1.0 um	1
DUFLUXU	tyx	Dust column u-wind mass flux	kg m^{-2} s^{-1}
DUFLUXV	tyx	Dust column v-wind mass flux	kg m^{-2} s^{-1}
DUSCAT25	tyx	Dust Scattering AOT [550 nm] - PM 2.5	1
DUSCATAU	tyx	Dust Scattering AOT [550 nm]	1
DUSCATFM	tyx	Dust Scattering AOT [550 nm] - PM 1.0 um	1
DUSD001	tyx	Dust Sedimentation Bin 001	kg m^{-2} s^{-1}
DUSD002	tyx	Dust Sedimentation Bin 002	kg m^{-2} s^{-1}
DUSD003	tyx	Dust Sedimentation Bin 003	kg m^{-2} s^{-1}
DUSD004	tyx	Dust Sedimentation Bin 004	kg m^{-2} s^{-1}
DUSD005	tyx	Dust Sedimentation Bin 005	kg m^{-2} s^{-1}
DUSMASS	tyx	Dust Surface Mass Concentration	kg m^{-3}
DUSMASS25	tyx	Dust Surface Mass Concentration - PM 2.5	kg m^{-3}
DUSV001	tyx	Dust Convective Scavenging Bin 001	kg m^{-2} s^{-1}
DUSV002	tyx	Dust Convective Scavenging Bin 002	kg m^{-2} s^{-1}
DUSV003	tyx	Dust Convective Scavenging Bin 003	kg m^{-2} s^{-1}
DUSV004	tyx	Dust Convective Scavenging Bin 004	kg m^{-2} s^{-1}
DUSV005	tyx	Dust Convective Scavenging Bin 005	kg m^{-2} s^{-1}
DUWT001	tyx	Dust Wet Deposition Bin 001	kg m^{-2} s^{-1}
DUWT002	tyx	Dust Wet Deposition Bin 002	kg m^{-2} s^{-1}
DUWT003	tyx	Dust Wet Deposition Bin 003	kg m^{-2} s^{-1}
DUWT004	tyx	Dust Wet Deposition Bin 004	kg m^{-2} s^{-1}
DUWT005	tyx	Dust Wet Deposition Bin 005	kg m^{-2} s^{-1}
LWI	tyx	land(1) water(0) ice(2) flag	1

OCANGSTR	tyx	Organic Carbon Angstrom parameter [470-870 nm]	1
OCCMASS	tyx	Organic Carbon Column Mass Density	kg m^{-2}
OCDP001	tyx	Organic Carbon Dry Deposition Bin 001	kg m^{-2} s^{-1}
OCDP002	tyx	Organic Carbon Dry Deposition Bin 002	kg m^{-2} s^{-1}
OCEM001	tyx	Organic Carbon Emission Bin 001	kg m^{-2} s^{-1}
OCEM002	tyx	Organic Carbon Emission Bin 002	kg m^{-2} s^{-1}
OCEMAN	tyx	Organic Carbon Anthropogenic Emissions	kg m^{-2} s^{-1}
OCEMBB	tyx	Organic Carbon Biomass Burning Emissions	kg m^{-2} s^{-1}
OCEMBF	tyx	Organic Carbon Biofuel Emissions	kg m^{-2} s^{-1}
OCEMBG	tyx	Organic Carbon Biogenic Emissions	kg m^{-2} s^{-1}
OCEXTTAU	tyx	Organic Carbon Extinction AOT [550 nm]	1
OCFLUXU	tyx	Organic Carbon column u-wind mass flux	kg m^{-1} s^{-1}
OCFLUXV	tyx	Organic Carbon column v-wind mass flux	kg m^{-1} s^{-1}
OCHYPHIL	tyx	Organic Carbon Hydrophobic to Hydrophilic	kg m^{-2} s^{-1}
OCSCATAU	tyx	Organic Carbon Scattering AOT [550 nm]	1
OCSMASS	tyx	Organic Carbon Surface Mass Concentration (Particulate Matter)	kg m^{-3}
OCSV001	tyx	Organic Carbon Convective Scavenging Bin 001	kg m^{-2} s^{-1}
OCSV002	tyx	Organic Carbon Convective Scavenging Bin 002	kg m^{-2} s^{-1}
OCWT001	tyx	Organic Carbon Wet Deposition Bin 001	kg m^{-2} s^{-1}
OCWT002	tyx	Organic Carbon Wet Deposition Bin 002	kg m^{-2} s^{-1}
SO2CMASS	tyx	SO2 Column Mass Density	kg m^{-2}
SO2EMAN	tyx	SO2 Anthropogenic Emissions	kg m^{-2} s^{-1}
SO2EMBB	tyx	SO2 Biomass Burning Emissions	kg m^{-2} s^{-1}
SO2EMVE	tyx	SO2 Volcanic (explosive) Emissions	kg m^{-2} s^{-1}
SO2EMVN	tyx	SO2 Volcanic (non-explosive) Emissions	kg m^{-2} s^{-1}
SO2SMASS	tyx	SO2 Surface Mass Concentration	kg m^{-3}
SO4CMASS	tyx	SO4 Column Mass Density	kg m^{-2}
SO4EMAN	tyx	SO4 Anthropogenic Emissions	kg m^{-2} s^{-1}
SO4SMASS	tyx	SO4 Surface Mass Concentration	kg m^{-3}
SSAERIDX	tyx	Sea Salt TOMS UV Aerosol Index	1
SSANGSTR	tyx	Sea Salt Angstrom parameter [470-870 nm]	1
SSCMASS	tyx	Sea Salt Column Mass Density	kg m^{-2}
SSCMASS25	tyx	Sea Salt Column Mass Density - PM 2.5	kg m^{-2}
SSDP001	tyx	Sea Salt Dry Deposition Bin 001	kg m^{-2} s^{-1}

SSDP002	tyx	Sea Salt Dry Deposition Bin 002	kg m^{-2} s^{-1}
SSDP003	tyx	Sea Salt Dry Deposition Bin 003	kg m^{-2} s^{-1}
SSDP004	tyx	Sea Salt Dry Deposition Bin 004	kg m^{-2} s^{-1}
SSDP005	tyx	Sea Salt Dry Deposition Bin 005	kg m^{-2} s^{-1}
SSEM001	tyx	Sea Salt Emission Bin 001	kg m^{-2} s^{-1}
SSEM002	tyx	Sea Salt Emission Bin 002	kg m^{-2} s^{-1}
SSEM003	tyx	Sea Salt Emission Bin 003	kg m^{-2} s^{-1}
SSEM004	tyx	Sea Salt Emission Bin 004	kg m^{-2} s^{-1}
SSEM005	tyx	Sea Salt Emission Bin 005	kg m^{-2} s^{-1}
SSEXTT25	tyx	Sea Salt Extinction AOT [550 nm] - PM 2.5	1
SSEXTTAU	tyx	Sea Salt Extinction AOT [550 nm]	1
SSEXTTFM	tyx	Sea Salt Extinction AOT [550 nm] - PM 1.0 um	1
SSFLUXU	tyx	Sea Salt column u-wind mass flux	kg m^{-1} s^{-1}
SSFLUXV	tyx	Sea Salt column v-wind mass flux	kg m^{-1} s^{-1}
SSSCAT25	tyx	Sea Salt Scattering AOT [550 nm] - PM 2.5	1
SSSCATAU	tyx	Sea Salt Scattering AOT [550 nm]	1
SSSCATFM	tyx	Sea Salt Scattering AOT [550 nm] - PM 1.0 um	1
SSSD001	tyx	Sea Salt Sedimentation Bin 001	kg m^{-2} s^{-1}
SSSD002	tyx	Sea Salt Sedimentation Bin 002	kg m^{-2} s^{-1}
SSSD003	tyx	Sea Salt Sedimentation Bin 003	kg m^{-2} s^{-1}
SSSD004	tyx	Sea Salt Sedimentation Bin 004	kg m^{-2} s^{-1}
SSSD005	tyx	Sea Salt Sedimentation Bin 005	kg m^{-2} s^{-1}
SSSMASS	tyx	Sea Salt Surface Mass Concentration	kg m^{-3}
SSSMASS25	tyx	Sea Salt Surface Mass Concentration - PM 2.5	kg m^{-3}
SSSV001	tyx	Sea Salt Convective Scavenging Bin 001	kg m^{-2} s^{-1}
SSSV002	tyx	Sea Salt Convective Scavenging Bin 002	kg m^{-2} s^{-1}
SSSV003	tyx	Sea Salt Convective Scavenging Bin 003	kg m^{-2} s^{-1}
SSSV004	tyx	Sea Salt Convective Scavenging Bin 004	kg m^{-2} s^{-1}
SSSV005	tyx	Sea Salt Convective Scavenging Bin 005	kg m^{-2} s^{-1}
SSWT001	tyx	Sea Salt Wet Deposition Bin 001	kg m^{-2} s^{-1}
SSWT002	tyx	Sea Salt Wet Deposition Bin 002	kg m^{-2} s^{-1}
SSWT003	tyx	Sea Salt Wet Deposition Bin 003	kg m^{-2} s^{-1}
SSWT004	tyx	Sea Salt Wet Deposition Bin 004	kg m^{-2} s^{-1}
SSWT005	tyx	Sea Salt Wet Deposition Bin 005	kg m^{-2} s^{-1}
SUANGSTR	tyx	SO4 Angstrom parameter [470-870 nm]	1

SUDP001	tyx	Sulfate Dry Deposition Bin 001	kg m^{-2} s^{-1}
SUDP002	tyx	Sulfate Dry Deposition Bin 002	kg m^{-2} s^{-1}
SUDP003	tyx	Sulfate Dry Deposition Bin 003	kg m^{-2} s^{-1}
SUDP004	tyx	Sulfate Dry Deposition Bin 004	kg m^{-2} s^{-1}
SUEM001	tyx	Sulfate Emission Bin 001	kg m^{-2} s^{-1}
SUEM002	tyx	Sulfate Emission Bin 002	kg m^{-2} s^{-1}
SUEM003	tyx	Sulfate Emission Bin 003	kg m^{-2} s^{-1}
SUEM004	tyx	Sulfate Emission Bin 004	kg m^{-2} s^{-1}
SUEXTTAU	tyx	SO4 Extinction AOT [550 nm]	1
SUFLUXU	tyx	SO4 column u-wind mass flux	kg m^{-1} s^{-1}
SUFLUXV	tyx	SO4 column v-wind mass flux	kg m^{-1} s^{-1}
SUPMSA	tyx	MSA Prod from DMS Oxidation [column]	kg m^{-2} s^{-1}
SUPSO2	tyx	SO2 Prod from DMS Oxidation [column]	kg m^{-2} s^{-1}
SUPSO4AQ	tyx	SO4 Prod from Aqueous SO2 Oxidation [column]	kg m^{-2} s^{-1}
SUPSO4G	tyx	SO4 Prod from Gaseous SO2 Oxidation [column]	kg m^{-2} s^{-1}
SUPSO4WT	tyx	SO4 Prod from Aqueous SO2 Oxidation (wet dep) [column]	kg m^{-2} s^{-1}
SUSCATAU	tyx	SO4 Scattering AOT [550 nm]	1
SUSV001	tyx	Sulfate Convective Scavenging Bin 001	kg m^{-2} s^{-1}
SUSV002	tyx	Sulfate Convective Scavenging Bin 002	kg m^{-2} s^{-1}
SUSV003	tyx	Sulfate Convective Scavenging Bin 003	kg m^{-2} s^{-1}
SUSV004	tyx	Sulfate Convective Scavenging Bin 004	kg m^{-2} s^{-1}
SUWT001	tyx	Sulfate Wet Deposition Bin 001	kg m^{-2} s^{-1}
SUWT002	tyx	Sulfate Wet Deposition Bin 002	kg m^{-2} s^{-1}
SUWT003	tyx	Sulfate Wet Deposition Bin 003	kg m^{-2} s^{-1}
SUWT004	tyx	Sulfate Wet Deposition Bin 004	kg m^{-2} s^{-1}
TOTANGSTR	tyx	Total Aerosol Angstrom parameter [470-870 nm]	1
TOTEXTTAU	tyx	Total Aerosol Extinction AOT [550 nm]	1
TOTSCATAU	tyx	Total Aerosol Scattering AOT [550 nm]	1

tavg3hr_2d_asm_Nx: Surface Diagnostics

Frequency: *3-hourly from 22:30 UTC (time-averaged)*
Spatial Grid: *2D, single-level, full horizontal resolution*
Dimensions: *longitude=576, latitude=361, time=1*
Granule Size: *~43 MB*

Name	*Dim*	*Description*	*Units*
ALBEDO	tyx	surface albedo	1
ALBNF	tyx	surface albedo for near infrared diffuse	1
ALBNR	tyx	surface albedo for near infrared beam	1
ALBVF	tyx	surface albedo for visible diffuse	1
ALBVR	tyx	surface albedo for visible beam	1
ANPRCP	tyx	anvil precipitation	kg m^{-2} s^{-1}
ASNOW	tyx	fractional area of land snowcover	1
BASEFLOW	tyx	baseflow flux	kg m^{-2} s^{-1}
CCWP	tyx	grid mean conv cond water path diagnostic	kg m^{-2}
CLDHI	tyx	cloud area fraction for high clouds	1
CLDLO	tyx	cloud area fraction for low clouds	1
CLDMD	tyx	cloud area fraction for middle clouds	1
CLDRF	tyx	cloud top radiative forcing	W m^{-2}
CLDTT	tyx	total cloud area fraction	1
CM	tyx	surface exchange coefficient for momentum	kg m^{-2} s^{-1}
CN	tyx	surface neutral drag coefficient	1
CNPRCP	tyx	convective precipitation	kg m^{-2} s^{-1}
CQ	tyx	surface exchange coefficient for moisture	kg m^{-2} s^{-1}
CT	tyx	surface exchange coefficient for heat	kg m^{-2} s^{-1}
EMIS	tyx	surface emissivity	1
EVAP	tyx	evaporation from turbulence	kg m^{-2} s^{-1}
EVLAND	tyx	Evaporation land	kg m^{-2} s^{-1}
FLNS	tyx	surface net downward longwave flux	W m^{-2}
FLNSC	tyx	surface net downward longwave flux assuming clear sky	W m^{-2}
FLNSCNA	tyx	surface net downward longwave flux assuming clear sky and no aerosol	W m^{-2}
FRLAKE	tyx	fraction of lake	1
FRLAND	tyx	fraction of land	1

FRLANDICE	tyx	fraction of land ice	1
FROCEAN	tyx	fraction of ocean	1
FRSEAICE	tyx	ice covered fraction of tile	1
GHLAND	tyx	Ground heating land	W m^{-2}
GRN	tyx	greeness fraction	1
GUST	tyx	gustiness	m s^{-1}
H1000	tyx	height at 1000 mb	m
H250	tyx	height at 250 hPa	m
H500	tyx	height at 500 hPa	m
H850	tyx	height at 850 hPa	m
LAI	tyx	leaf area index	1
LHFX	tyx	total latent energy flux	W m^{-2}
LHLAND	tyx	Latent heat flux land	W m^{-2}
LSPRCP	tyx	nonanvil large scale precipitation	kg m^{-2} s^{-1}
LWLAND	tyx	Net longwave land	W m^{-2}
LWP	tyx	liquid water path	kg m^{-2}
LWS	tyx	surface absorbed longwave radiation	W m^{-2}
LWSC	tyx	surface absorbed longwave radiation assuming clear sky	W m^{-2}
LWSCNA	tyx	surface absorbed longwave radiation assuming clear sky and no aerosol	W m^{-2}
OLR	tyx	upwelling longwave flux at toa	W m^{-2}
OLRC	tyx	upwelling longwave flux at toa assuming clear sky	W m^{-2}
OLRCNA	tyx	upwelling longwave flux at toa assuming clear sky and no aerosol	W m^{-2}
OMEGA500	tyx	omega at 500 hPa	Pa s-1
OSR	tyx	toa outgoing shortwave flux	W m^{-2}
OSRCLR	tyx	toa outgoing shortwave flux assuming clear sky	W m^{-2}
OXFILL	tyx	vertically integrated ox adjustment from filling	kg m^{-2} s^{-1}
PBLH	tyx	planetary boundary layer height	m
PCU	tyx	convective rainfall	kg m^{-2} s^{-1}
PHIS	tyx	surface geopotential height	m+2 s-2
PLS	tyx	large scale rainfall	kg m^{-2} s^{-1}
Q10M	tyx	10-meter specific humidity	kg kg^{-1}
Q250	tyx	specific humidity at 250 hPa	kg kg^{-1}
Q2M	tyx	2-meter specific humidity	kg kg^{-1}
Q500	tyx	specific humidity at 500 hPa	kg kg^{-1}

Q850	tyx	specific humidity at 850 hPa	kg kg^{-1}
QA	tyx	surface specific humidity	kg kg^{-1}
QHAT	tyx	effective surface specific humidity	kg kg^{-1}
QS	tyx	surface specific humidity	kg kg^{-1}
QVFILL	tyx	vertically integrated qv adjustment from filling	kg m^{-2} s^{-1}
RADSRF	tyx	net downwelling radiation at surface	W m^{-2}
RADSWT	tyx	toa incoming shortwave flux	W m^{-2}
RASPBLQ	tyx	sqrt of integral KH dz	$(m^{+3}\ s^{-1})^{+1/2}$
RASTIME	tyx	timescale for deep RAS plumes	s
RHOS	tyx	air density at surface	kg m^{-3}
RISFC	tyx	surface bulk richardson number	1
RUNOFF	tyx	surface runoff flux	kg m^{-2} s^{-1}
SFCEM	tyx	longwave flux emitted from surface	W m^{-2}
SGH	tyx	isotropic stdv of GWD topography	m
SHFX	tyx	sensible heat flux from turbulence	W m^{-2}
SHLAND	tyx	Sensible heat flux land	W m^{-2}
SLRSF	tyx	surface incoming shortwave flux	W m^{-2}
SMLAND	tyx	Snowmelt flux land	kg m^{-2} s^{-1}
SNO	tyx	snowfall	kg m^{-2} s^{-1}
SNOMAS	tyx	snow mass	kg m^{-2}
SNOWDP	tyx	snow depth	m
SPEED	tyx	surface wind speed	m s^{-1}
SPLAND	tyx	rate of spurious land energy source	W m^{-2}
SPWATR	tyx	rate of spurious land water source	kg m^{-2} s^{-1}
SWCLDPRS	tyx	cloud top pressure	Pa
SWCLDTMP	tyx	cloud top temperature	K
SWGDWN	tyx	surface incoming shortwave flux	W m^{-2}
SWGDWNC	tyx	surface incoming shortwave flux assuming clear sky	W m^{-2}
SWGNET	tyx	surface net downward shortwave flux	W m^{-2}
SWGNETC	tyx	surface net downward shortwave flux assuming clear sky	W m^{-2}
SWGNETCNA	tyx	surface net downward shortwave flux assuming clear sky and no aerosol	W m^{-2}
SWGNETNA	tyx	surface net downward shortwave flux assuming no aerosol	W m^{-2}
SWLAND	tyx	Net shortwave land	W m^{-2}
SWTNET	tyx	toa net downward shortwave flux	W m^{-2}

SWTNETC	tyx	toa net downward shortwave flux assuming clear sky	W m^{-2}
SWTNETCNA	tyx	toa net downward shortwave flux assuming clear sky and no aerosol	W m^{-2}
SWTNETNA	tyx	toa net downward shortwave flux assuming no aerosol	W m^{-2}
T10M	tyx	10-meter air temperature	K
T250	tyx	air temperature at 250 hPa	K
T2M	tyx	2-meter air temperature	K
T500	tyx	air temperature at 500 hPa	K
T850	tyx	air temperature at 850 hPa	K
TA	tyx	surface air temperature	K
TAUHI	tyx	optical thickness of high clouds(EXPORT)	1
TAULO	tyx	optical thickness of low clouds	1
TAUMD	tyx	optical thickness of middle clouds	1
TAUTT	tyx	optical thickness of all clouds	1
TAUX	tyx	eastward surface stress	N m-2
TAUY	tyx	northward surface stress	N m-2
TAVE	tyx	vertically averaged dry temperature	K
TBC	tyx	total black carbon aerosol loading	kg m^{-2}
TDUST	tyx	total dust aerosol loading	kg m^{-2}
TELAND	tyx	Total energy storage land	J m-2
THAT	tyx	effective surface skin temperature	K
TOC	tyx	total organic carbon aerosol loading	kg m^{-2}
TPREC	tyx	total precipitation	kg m^{-2} s^{-1}
TPW	tyx	total precipitable water vapor	kg m^{-2}
TROPPB	tyx	tropopause pressure based on blended estimate	Pa
TROPPT	tyx	tropopause pressure based on thermal estimate	Pa
TROPPV	tyx	tropopause pressure based on EPV estimate	Pa
TROPQ	tyx	tropopause specific humidity using blended TROPP estimate	kg kg^{-1}
TROPT	tyx	tropopause temperature using blended TROPP estimate	K
TS	tyx	surface skin temperature	K
TSALT	tyx	total sea salt aerosol loading	kg m^{-2}
TSO4	tyx	total sulfate aerosol loading	kg m^{-2}
TSOIL1	tyx	soil temperatures layer 1	K
TTAUBC	tyx	total black carbon optical thickness in 0.4-0.690 band	1
TTAUDU	tyx	total dust optical thickness in 0.4-0.690 band	1

TTAUOC	tyx	total organic carbon optical thickness in 0.4-0.690 band	1
TTAUSO	tyx	total sulfate optical thickness in 0.4-0.690 band	1
TTAUSS	tyx	total salt optical thickness in 0.4-0.690 band	1
TWLAND	tyx	Avail water storage land	kg m^{-2}
U10M	tyx	10-meter eastward wind	m s^{-1}
U10N	tyx	equivalent neutral 10-meter eastward wind	m s^{-1}
U250	tyx	eastward wind at 250 hPa	m s^{-1}
U2M	tyx	2-meter eastward wind	m s^{-1}
U500	tyx	eastward wind at 500 hPa	m s^{-1}
U50M	tyx	50-meter eastward wind	m s^{-1}
U850	tyx	eastward wind at 850 hPa	m s^{-1}
US	tyx	surface eastward wind	m s^{-1}
USTAR	tyx	surface velocity scale	m s^{-1}
V10M	tyx	10-meter northward wind	m s^{-1}
V10N	tyx	equivalent neutral 10-meter northward wind	m s^{-1}
V250	tyx	northward wind at 250 hPa	m s^{-1}
V2M	tyx	2-meter northward wind	m s^{-1}
V500	tyx	northward wind at 500 hPa	m s^{-1}
V50M	tyx	50-meter northward wind	m s^{-1}
V850	tyx	northward wind at 850 hPa	m s^{-1}
VARFLT	tyx	isotropic variance of filtered topography	m+2
VENT	tyx	surface ventilation velocity	m s^{-1}
VS	tyx	surface northward wind	m s^{-1}
WET1	tyx	surface soil wetness	1
Z0	tyx	surface roughness	m
Z0H	tyx	surface roughness for heat	m